## WILLBRIDGE TERMINALS

Oregon DEQ File Number: WMCSR-NWR-94-06

ConocoPhillips 5528 NW Doane, Chevron 5531 NW Doane and Kinder Morgan 5880 NW St. Helens Road.
DEQ Site Mgr: Ms. Jill Kiernan
Latitude: 45.56506
Longitude: 122.73910
Township/Range/Section: T1N/R1E/18 & 19 and T1N/R1W/13

River Mile: 7.5 West bank

LWG Member ☒ Yes ☐ No

Upland Analytical Data Status: ☒ Electronic Data Available ☐ Hardcopies only

## 1. SUMMARY OF POTENTIAL CONTAMINANT TRANSPORT PATHWAYS TO THE RIVER

The current understanding of the transport mechanism of contaminants from the uplands portion of the site to the river is summarized in this section and Table 1.

The general potential migration pathways include movement of released contaminants through air, soil, groundwater and surface water. The air pathway results from releases where a portion of the material volatilized into the ambient air and was dispersed by prevailing winds. The soil and groundwater migration potential pathways typically result from a portion of the released material penetrating into the predominantly sandy silt surface soils and downward through the soil column to the subsurface soils. In the case of the larger releases, the materials may penetrate the subsurface soil to the groundwater, which has been observed at the site ranging in depths from 4 to 22 feet below grade. If groundwater is reached, the insoluble components of the released material, such as the separate phase hydrocarbons (SPHs), will generally form a lens on the groundwater surface whereas the more soluble components will most likely dissolve into the groundwater. Both the SPH and dissolved components would typically migrate in the direction of groundwater flow and undergo various natural attenuation processes such as biodegradation, adherence to soil particles, geochemical degradation, and others. Depending on contaminant concentrations and/or quantity of SPH, proximity to surface water, rate of groundwater movement, and presence of preferential pathways, contaminants could reach the Willamette River. Due to the presence of containment structures, stormwater treatment facilities, and application of best management practices at each facility, the potential for contaminant migration via surface water is extremely low.

The current specific pathways are the area of the former 27-inch storm sewer pipe backfill and outfall (a portion of the 27-inch storm sewer pipeline has been removed and the remainder was grouted in place), the former Holbrook Slough that connected Kittridge Lake with the Willamette River prior to the area being filled in with dredge spoils in the early 1900s, and the two groundwater seeps located on the Kinder Morgan Liquid Terminals, LLC (KMLT) property near the KMLT dock. The two groundwater seeps on the KMLT property that discharge to the Willamette River are potential preferential pathways, however;

sampling of these seeps indicated petroleum hydrocarbons are not present. The mitigated pathway is the backfill around the 60-inch stormwater pipeline and outfall which has now been cut off with a 170-foot-long sheet pile wall with extraction wells behind the wall to remove and treat impacted groundwater.

## *1.1 Overland Transport*

The ability for impacted surface soils to move significant distances by erosion and water transport is very limited. Operating areas around above ground storage tanks (ASTs) and loading/unloading areas are gravel covered or paved, and equipped with containment berms or perimeter walls. Storm and process water generated from the tank farm, truck loading and unloading, former drum reconditioning and other potential spill areas is captured in the bermed/walled areas and routed to oil/water separators and/or other pollution control equipment for treatment. Treated stormwater is generally discharged to the municipal storm drain system and then to the Willamette River whereas treated process water is typically discharged to the local POTW via the municipal sanitary sewer system. Stormwater runoff from roof drains and non-oil storage or transfer areas (e.g. parking lots, driveways, general open space) generally drains to catch basins and then directly to the municipal storm drain system without treatment. Storm and process water collected from operating areas is discharged from the facilities under permit and is routinely sampled. These facility water collection and treatment systems and containment features serve to severely limit or essentially eliminate the transport of impacted surface soils off-site.

## *1.2 Groundwater*

Groundwater is first encountered beneath the facility at depths ranging from approximately 4 to 22 feet below grade within sandy dredge spoils fill material. A layer of alluvium underlies the fill deposit. The alluvium consists of a complex inter-layering of clayey/silt soils. Columbia River Basalts were encountered in two geotechnical borings on the Chevron terminal at a depth of approximately 50 feet below grade in the western portion of the site. A geotechnical boring near the river on the Chevron terminal did not intersect the Columbia River Basalts at the total depth explored at 60 feet below grade (elevation -27 feet). Borings in the river for sediment samples did not intersect the Columbia River Basalts at the total depth explored (elevation -43 feet). The Columbia River Basalts form the main regional aquifer.

The contaminants of potential concern (COPCs) identified in soil and groundwater media at the Site and associated with the various refined petroleum products released can be arranged into three broad groups of chemicals: volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons (PAHs), and metals. The environmental fate and transport of compounds in each of these chemical groups are widely different, owing to their distinct chemical properties.

Data collected during a study at the Chevron terminal suggests that there are areas on the site where there is an upward groundwater gradient. Therefore with the existence of the site wide silt layer below the first occurrence of groundwater and the observed upward groundwater gradient, it doesn't appear likely that the underlying Columbia River Basalt aquifer could be affected by the shallower dissolved petroleum hydrocarbons located in the upper alluvium aquifer.

Based on the Final Upland RI Report for the Willbridge Terminals (dated August 1, 2003) and the groundwater monitoring reports, the groundwater gradient at the Willbridge Terminals appears to be toward the Willamette River. One mitigated and three potential current specific subsurface migration pathways from the site to the river have been identified as past or current seeps to the river.

- The mitigated pathway is the backfill around the 60-inch stormwater pipeline and outfall which has now been cut off with a 170-foot-long sheet pile wall with extraction wells behind the wall to remove and treat impacted groundwater.

- One potential migration pathway is associated with either the former Holbrook Slough or the City's former 27-inch diameter sewer. Both of these pathways discharge to the river in the same area. The former 27-inch sewer was a wood-stave storm sewer outfall managed by the City of Portland until replaced in 1982 by the above 60-inch outfall. The former Holbrook Slough connected Kittridge Lake with the Willamette River prior to the area being filled in with dredge spoils in the early 1900s. Historically, a seep containing SPH had been reported from the area of the 27-inch outfall. The seep is primarily water with minor amounts of SPH, which has been fingerprinted as weathered diesel fuel-range hydrocarbons from historic releases. The seep occurs periodically, associated with fluctuations in the groundwater and river elevations.

    - The Holbrook Trench Recovery System was installed in 1988 to mitigate an SPH seep at the ConocoPhillips/Chevron property line that resulted in localized sheens on the river. The system consists of an L-shaped trench with a polypropylene liner situated across the mouth of the historic Holbrook Slough and the outfall area of the former 27-inch sewer. A recovery sump is located at the junction of the two legs. Total fluids were pumped from the sump to the Chevron API separator for treatment and disposal to the City of Portland sanitary sewer system. The system operated from 1988 until 1993 when it was shut down due to lack of SPH recovery. Between 1993 and 2002 only a few sheens of limited extent were noted in the vicinity of the seep. In response to an increase in the frequency of sheens in 2002, the Holbrook Trench Recovery System was reactivated during periods of low river levels since the trench would become flooded with river water above a river level of 7 feet. Operation of the system has continued on an intermittent basis since the summer of 2002.

    - Upstream of the Holbrook Trench, an additional temporary SPH recovery sump installed in 2002. The presence of SPH in the sump is variable from month to month. When present, the recovery rate of SPH is two to four gallons per month. The recovery sump is also effective, except when the system is flooded by the river during high water periods.

    - A double boom system contains any remaining petroleum sheen. A monitoring well network has been installed to measure groundwater elevation, SPH thickness, and groundwater quality.

    - A sheet pile cut-off wall has been designed to cut off this pathway. Installation is scheduled for Fall of 2004. The design consists of a near linear, 200-foot-length sheet-pile wall along the shoreline in the area between the Chevron and ConocoPhillips docks. Similar to the existing cutoff wall around the 60-inch outfall, extraction wells will be installed behind the wall to remove impacted groundwater and recovery SPH. The existing treatment system for the 60-inch cutoff wall will be used to separate any recovered SPH and treat impacted groundwater.

- Two groundwater seeps located on the Kinder Morgan Liquid Terminals, LLC (KMLT) property near the KMLT dock. The two groundwater seeps on the KMLT property are potential pathways, however; sampling of these seeps indicated petroleum hydrocarbons are not present.

## 1.3 Direct Discharge (Overwater Activities and Stormwater/Wastewater Systems)

The three terminals have docks for loading and unloading petroleum product. The potential exists for direct discharge via releases during petroleum transfer operations at the marine dock for each facility although these releases are rare and involve very small quantities. Strict adherence to US Coast Guard requirements and the application of best management practices further minimizes the potential for direct discharges. The docks have containment booms and emergency response equipment, including boats and adsorbent booms.

In 1989, during loading of a ship, 6,300 gallons of asphalt were released to the river due to a pipe failure at the Chevron dock. The release was quickly contained by a triple boom system. The asphalt was removed by vacuum trucks and by hand shoveling into drums. The water, river bottom, and shoreline were remediated. The U.S. Coast Guard was the lead agency and approved the completion of cleanup activities.

Stormwater discharges from the site are routed through City of Portland Storm Outfall 22, Saltzman Creek and private stormwater outfalls at Chevron and ConocoPhillips. The potential for direct discharges via stormwater or wastewater systems is also minimal as discussed above in Section 1.1.

## 1.4 Riverbank Erosion

The Willbridge Terminal's dock facilities are located within a cove, reducing potential for riverbank erosion due to river flow. The riverbank adjacent to the terminal docks is armored with rip rap to prevent erosion from wave action and prop wash. A sand beach has formed along the rip rap. The area adjacent to the docks is a depositional area and requires periodic dredging to maintain an open berth.

## 1.5 Relationship of Upland Sources to River Sediments

*[This section provides sediment transport information relative to Sediment Transport Analysis, Sediment Profile Images, and bathymetric surveys conducted by the LWG in the river. This section will be completed by the LWG]*

## 1.6 Sediment Transport

The Willbridge bulk fuel facility is located on the western shore of the Willamette River in the embayment immediately upstream of the ATOFINA property. Three large finger piers extend outward from the facility to the main river stem. The Sediment Trend Analysis[O] showed that the Willbridge Terminals embayment is fully depositional. The river outside of the embayment is relatively wide and appears to be fully depositional based on Sediment Trend Analysis[O] and sediment-profile image survey results (Integral et al. 2004). The time-series bathymetric change data over the 25-month period from January 2002 through February 2004 (Integral and DEA in prep.) show the effects of dredging around the downstream and upstream piers extending riverward into the navigation channel with some areas showing up to five to ten feet of sediment excavation. A smaller area of sediment accumulation (up to five feet in extent) is evident beneath and along the length of the central pier, particularly at the shoreward end. The relatively shallow (< 20 ft NAVD88) bench area at the downstream end of the embayment is a mosaic of areas showing sediment scour, accretion, and no change. A nearly continuous narrow band of sediment scour on the order of 1 ft in extent is evident along the shoreward edge of the entire embayment above the –10 ft NAVD88 contour.

Periodic sediment stake monitoring was conducted along the beach at the downstream corner of the Willbridge Terminals enbayment at elevations of +7, +9, and +16 ft (NAVD88) from July 2002 to January 2004. The lowest stake (+7) showed 13 cm of erosion through December 2002, followed by 15 cm of accretion through March 2003, and then 12 cm of erosion through November 2003 (Anchor 2004). Overall, this is consistent with the general erosion pattern seen in the narrow band just offshore. The mid-beach stake (+ 9) also showed erosion of up to 17 cm through March 2003 and then was lost. The high stake (+16) showed either no change or slight accretion (2-4 cm) throughout the period of observation.

Anchor Environmental. 2004. Sediment Stake Erosion/Accretion Monitoring Report, July 2002 – January 2004, Portland Harbor RI/FS. Prepared for the Lower Willamette Group. Prepared by Anchor Environmental, L.L.C. (Seattle, WA).

Integral and DEA. 2004. In preparation. Lower Willamette River February 2004 Multibeam Bathymetric Survey Report. Draft. Prepared for Lower Willamette Group, Portland, OR. Prepared by Integral Consulting, Inc. (Olympia, WA) and David Evans and Associates, Inc. (Portland, OR).

## 2. CSM SITE SUMMARY REVISIONS

Date of Last Revision: August 19, 2004

## 3. PROJECT STATUS

| Activity | | Date(s)/Comments |
|---|---|---|
| PA/XPA | ☒ | Preliminary Assessment, Chevron Terminal, June 15, 1994 |
| RI | ☒ | Consent Decree WMCSR-NWR-94-06/ April 6, 1994 |
| FS | ☒ | Consent Decree WMCSR-NWR-94-06/ April 6, 1994 |
| Interim Action/Source Control | ☒ | Preliminary Source Control Evaluation April 2003 |
| ROD | ☐ | |
| RD/RA | ☐ | |
| NFA | ☐ | |

Department of Environmental Quality (DEQ) Portland Harbor Site Ranking (Tier 1, 2, or 3): ConocoPhillips Company and Chevron Products Company are Tier 1 and Kinder Morgan Energy Partners is Tier 2.

## 4. SITE OWNER HISTORY

The following information is based on the RI report prepared in 2003. The following table presents the ownership history for each of the three terminals that compose the Willbridge Terminals Site. Figure 1 shows the location of the three terminals.

| Owner/Occupant | Type of Operation | Years |
|---|---|---|
| **Chevron Products Company Terminal**<br>This was known as the Standard Oil Terminal until approximately 1976. | Bulk Petroleum Storage | 1911 to present |
| **KMLT Terminal**<br>Following signing of the Consent Order, control of the Shell Willbridge Plant was transferred to GATX Terminals Corporation (GATX) by sale agreement on November 23, 1994, with Shell retaining a portion of the environmental responsibility for the terminal. On March 1, 2003, the GATX terminal was sold to KMLT. | Bulk Petroleum Storage | 1914 to present |
| **ConocoPhillips Company**<br>Unocal constructed the Portland Terminal in 1908 and continued to own and operate it until March 31, 1997 when it was transferred to Tosco Refining Company (Tosco) by sale agreement. Under the agreement, Tosco assumed remedial management responsibilities with Unocal retaining ultimate environmental liability. On September 18, 2001, the Tosco facility was purchased by Phillips Petroleum Company who subsequently merged with Conoco on September 1, 2002 forming the ConocoPhillips Company. As with Tosco, ConocoPhillips is responsible for managing remedial activities at the Portland Terminal on behalf of Unocal. | Bulk Petroleum Storage | 1908 to present |

## 5. PROPERTY DESCRIPTION

The ConocoPhillips Terminal at the Willbridge Terminals Site consists of approximately 30 acres of flat terrain with limited ruderal on-site vegetation. The majority of the site is paved with asphalt or surfaced with gravel for industrial use. A small (less than one acre) sandy beach area is located in the northeast corner of the terminal adjacent to the Willamette River and is sparsely landscaped with planted shrubs as part of the City of Portland's Willamette River Greenway Overlay zone.

The Chevron Terminal consists of approximately 16 acres of flat terrain with limited ruderal on-site vegetation. The majority of the site is paved with asphalt or gravel for industrial use. The waterfront area consists of riprap and gravel with sparse landscaping in the form of native or planted shrubs.

The KMLT Terminal consists of approximately 37 acres of flat terrain with limited on-site vegetation. The site is approximately 85 percent ruderal, with the majority of the site paved with asphalt or gravel for industrial use.

The Willbridge Terminals Site is located in Portland's Northwest Industrial District (District). The District is generally zoned by the City of Portland as heavy industrial (IH) with some sections included in the river heavy industrial overlay (IHi). Per the City of Portland Zoning Code 33.140.030(F), the heavy industry zoning "…Provides areas where all kinds of industries may locate including those not desirable in appearance. The development standards are the minimum necessary to assure safe, functional efficient and environmentally sound development." Furthermore, the region east of St. Helens Road is designated as an Industrial Sanctuary. City of Portland Policy 10.4(21) defines the industrial sanctuary classification as "…intended for areas where city policy is to reserve land for existing and future industrial development. A full range of industrial uses are permitted and encouraged. Non-industrial uses are limited to prevent land use conflicts and to preserve land for industry."

The entire site is zoned IH with an "i" designation which indicates the waterfront area is within the River Industrial Greenway Overlay (City of Portland, 1999). The IH zoning allows a variety of industrial activities, including the current use of the site. The "i" designation is for river dependent or river related uses that "strengthen the economic vitality of Portland as a marine shipping and industrial harbor, while preserving and enhancing the riparian habitat and providing public access where practical" (City of Portland, 1987).

## 6. CURRENT SITE USE

The Chevron Willbridge Distribution Center stores and distributes a variety of refined petroleum products, including gasoline diesel fuel, and lubricating oil. The terminal began operations in 1911 and operates 179 tanks with an aggregate capacity of approximately 63 million gallons.

The KMLT terminal stores a range of petroleum products, including diesel, gasoline, ethanol, and aviation fuel. Historically KMLT also stored fuel oils, motor oil and lubrication oils. The terminal began petroleum-storage operations in 1914. The KMLT terminal has 141 above ground tanks. Currently, only 20 of these tanks are in use for petroleum product storage. These tanks that are currently in use have a usable capacity of approximately 29 million gallons.

The ConocoPhillips terminal stores and transfers a variety of bulk petroleum products, including gasoline, diesel, fuel oils and lubricants and blends and packages a variety of lubricants as well. Petroleum-handling operations at the ConocoPhillips terminal began in 1908 with just a few tanks and buildings.

The terminal currently contains 119 storage tanks with an aggregate capacity of approximately 36 million gallons and includes three tank truck loading racks, four tank truck unloading stations, a rail car loading and unloading rack, a marine transfer dock, a lubricant blending facility, three warehouses, a maintenance building and several office areas.

## 7. SITE USE HISTORY

While ownership has changed, the three original petroleum product terminals (Union Oil/ConocoPhillips, Standard Oil/Chevron Products Company, and Shell Oil/KMLT) included in this CSM are still operational and have been in operation since the early 1900s.

## 8. CURRENT AND HISTORIC SOURCES AND COPCS

The understanding of historic and current potential upland and overwater sources at the site is summarized in Table 1. The following sections provide a brief overview of the potential sources and COPCs at the site requiring additional discussion.

Surface spills of refined petroleum products appear to be the primary release mechanism for petroleum hydrocarbons and other chemicals observed in soil and groundwater at the Site.

### *8.1 Uplands*

The volumes of documented releases at the Willbridge Terminals site of petroleum products range from one gallon to 126,000 gallons. The more significant releases were associated with inadvertent discharges from ASTs as the result of plug failures and overfilling as well as railroad tank car spillage and pipeline failures. As presented in the Final Upland RI Report, the total volume of documented releases is approximately 327,234 gallons. Materials released include: “medium aromatics” (126,000 gallons), gasoline (52,800 gallons), xylene (45,000 gallons), ethanol (19,000 gallons), various types of oils (13,100 gallons), and toluene (6,000 gallons). Attempts were made to recover the material at the time of the releases although the older records do not generally quantify the volume recovered.

Based upon the results of the RI sampling and analytical program, a list of COPCs was developed for the site to include only those contaminants that were positively identified in soil, groundwater, surface water or sediments somewhere within the Willbridge Terminals Site. These COPCs from Appendix E of the RI are:

- Aromatic volatile organics (e.g. benzene, toluene, ethylbenzene and xylenes (BTEX)) related to gasoline product releases.
- PAH compounds related to diesel/heavy oil product releases.
- Metals (defined as arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver and zinc) generally associated with the heavier oils and fuels with the exception of lead that historically was used as a gasoline additive.

### *8.2 Overwater Activities* ☒ *Yes* ☐ *No*

Each of the three terminals which compose the Willbridge Terminals Site have a marine dock for the loading and unloading of petroleum products to or from tankers, barges and tug boats.

### *8.3 Spills*

Known or documented spills at the Willbridge Terminals site were obtained either from DEQ SPINS database for the period of 1995 to 2003, from oil and chemical spills recorded from 1982 to 1989 by the U.S. Coast Guard and the National Response Center's centralized federal database [see Appendix E of the Portland Harbor Work Plan (Integral et al. 2004)], from DEQ correspondence and from internal files at the individual facilities. See supplemental Tables 1, 2, 3 from KHM's August 1, 2003, *Final Upland Remedial Investigation Report* (Tables 1, 2 and 3 are attached).

## 9. PHYSICAL SITE SETTING

### *9.1 Geology*

The site lies on the northeastern flank of the northeast dipping Tualatin Mountain anticline. Fill material of gravel, silt and sand has been deposited over most of the site, covering the Holocene alluvial deposits of clay, silt and sand. The alluvium overlies the Columbia River Basalts. Figure 4 presents a geologic cross section of the subsurface beneath the site.

There have been more than 95 soil borings installed at the site. These include the B-series (1 through 41) installed at the Chevron and ConocoPhillips terminals, the CR-series (1 through 11) at the Chevron terminal, the MW-series (1 through 40) installed at the KMLT terminal, RES-N, RES-O, IT-E, IT-W and the U-series (1 through 4) installed at the ConocoPhillips terminal. Most borings were completed as monitoring wells. These soil borings have helped define the interface between the fill material and the underlying alluvium and have allowed for evaluation of groundwater depth and quality.

The site soil profile is typified by a layer of fill covering alluvium. The source of the fill is primarily Willamette River dredging. The fill is very loose to medium dense and fine to medium grained sand and silty sand. The thickness of the fill material ranges from nonexistent to greater than 30 feet. There is relatively little fill in the KMLT terminal's south tank yard, while there are significant fill areas on the rest of the site.

In general, the alluvium is very soft to medium stiff clayey silt with sand and organics. The alluvium is often inter-bedded with silty clays and clays. The alluvium is initially encountered between ground level and depths of 20-30 feet below grade at the site. The thickness of this unit has been explored on-site within the Chevron tank farm. In two geotechnical borings, the alluvium extended from a depth of approximately 25 feet below grade to approximately 50 feet below grade.

Based on these two geotechnical borings in the Chevron Tank yard, Columbia River Basalts are present at approximately 50 feet below grade. The flows, which date from the Miocene age, are jointed and usually have rubble or vesicular tops which contain most of the groundwater.

Surface samples of on-site soils were collected to evaluate the lateral extent of COPC impacts to the site resulting from previous practices. Fifty-four surface soil sampling locations were selected at the site. Sixteen sample locations are located on the ConocoPhillips terminal, 22 on the KMLT terminal and 16 on the Chevron terminal. Samples were spaced on a 300 by 300-foot grid, with minor adjustments for yard structures such as tanks or piping. Samples were collected at a depth interval of 0 to 6 inches below ground surface.

The RI subsurface soil investigation collected data to define the locality of the facility, investigate preferential pathways such as buried utilities, to evaluate the beneficial uses of water and to assess the risks of site related contaminants to human and ecological receptors. Subsurface soil samples collected during the RI were collected using continuous direct-push (Hydropunch or similar) methods. Continuous logging was performed for each of the borings, beginning at the surface and continuing to the total depth explored for visual observation and classification. Borings were completed to the top of the low permeability silt-clay layer that has been identified as laterally continuous across the site. The approximate depth of this layer is 25 to 30 feet below grade west of Front Avenue and reduces in depth moving towards the river.

The site is located in the Doane Lake Area. The area once contained several small lakes, including Kittridge and Doane Lakes, as well as sloughs. Much of the site is located on historic Kittridge Lake. These lakes and sloughs were filled with dredge materials from the Willamette River. The pre-fill topography is important to current groundwater migration pathways. In the area near the Willamette River, groundwater levels are affected by changes in the Willamette River stage.

## *9.2 Hydrogeology*

Currently, there are 143 groundwater monitoring wells in the monitoring well network for the site. The groundwater gradient, based on the groundwater-monitoring data collected during the latest sampling event in March 2004, is east towards the Willamette River at a magnitude of approximately 0.02 foot/foot (Figure 2). This is generally consistent with previous monitoring events.

There are three active groundwater seeps at the Willbridge Terminals site. Two of these seeps are located near the Kinder Morgan dock. The third seep is located on the property line between Chevron and ConocoPhillips in the location of the former 27-inch outfall and the former Holbrook Slough.

The site lies outside the Willamette River 500-year floodplain. The Saltzman Creek watershed is the primary means of groundwater recharge for the area. The creek drains approximately 840 acres in the Tualatin Mountains, which lie to the southwest of the site and is channeled in a flume near the center of the KMLT terminal. The average stream flow for Saltzman Creek is estimated at three to four cubic feet per second (cfs) and varies seasonally. Facility runoff flows through the Doane Avenue storm drain and is not directed through the Saltzman Creek flume.

The topography of the Willbridge Facility is relatively flat with a gradual downward slope towards the Willamette River. The facility elevation is between 30 and 40 feet above the national geodetic vertical datum of 1929. The Willamette River ranges in elevation from a high tide elevation of approximately 16 feet above mean sea level (MSL) to a low tide elevation of approximately 5 feet above MSL. The average daily tidal influence brings a fluctuation of two to three feet to the Willamette River. Percolation principally occurs at the site in the graveled tank yards, unpaved rail areas and other unpaved areas.

A total of three seep-water samples (Seep 1, Seep 2 and Seep 27) were collected from two seep locations on the KMLT terminal (Seep 1 and Seep 2) and one near the ConocoPhillips/Chevron property line (Seep 27). Seep 1 was collected under the KMLT dock. Seep 2 was collected to the north of the KMLT dock in the beach area. These samples were collected during April of 2003. The seep sample from the

ConocoPhillips/Chevron property line was collected near the location of the former 27-inch storm sewer outfall and mouth of the former Holbrook Slough. This sample was collected on July 3, 2003.

## 10. NATURE AND EXTENT *(Current Understanding)*

The current understanding of the nature and extent of contamination for the uplands portions of the site is summarized in this section. The RI captures the nature and extent of previous investigations for data that could be evaluated. Based upon the groundwater flow and quality data, the extent of dissolved and/or soil bound petroleum hydrocarbons is described as follows:

- The southwestern edge of the facilities along the Burlington Northern Santa Fe Railroad right-of-way.
- Along NW 61st Avenue along the boundary of the KMLT Terminal.
- A portion of the McCall Oil Company property adjacent to the ConocoPhillips terminal.
- A portion of the CertainTeed Roofing facility.
- Along the shoreline of the Willamette River on the ConocoPhillips and Chevron Terminals.

## *10.1 Soil*

### 10.1.1 Upland Soil Investigations ☒ Yes ☐ No

Surface soils and subsurface soils were sampled during the RI field activities. Surface soils were identified with an SS in the sample ID (i.e., T-SS 1). Subsurface samples were identified with an HP (hydropunch), an HS (hot spot hydropunch), a RF (river front hydropunch), or a UB (utility boring) in the sample ID. A total of 54 surface soil samples were collected and analyzed. One hundred ten subsurface soil samples were collected from the HP, RF, and UB sample locations. An additional 16 subsurface soil samples were collected from surrogate "hot spot" locations on the KMLT and ConocoPhillips terminals (eight samples from four borings at each facility). Figures presenting the distribution of the analytical results are presented in the Final Upland RI Report dated August 1, 2003.

The RI reported the following maximum concentrations of contaminants of interest:

Upland Soil Investigation

A summary of the soil sampling results from each of the three terminals that comprise the Willbridge Terminal, as presented in Appendix E of the Final Upland Remedial Investigation Report, (KHM Environmental Management, August 1, 2003) is presented below for the contaminants of concern. The table for each of the three terminals shows the minimum and maximum of the concentrations detected above the laboratory method reporting limits (MRLs) and the range of MRLs.

**Kinder Morgan:**

| Analyte | Detect Range (min. – max.) | MRL range (min. – max.) |
|---|---|---|
| **VOCs** (in mg/kg) | | |
| 1,2,4 – Trimethylbenzene | 0.71 (one detection) | 0.1 |

| | | |
|---|---|---|
| 1,3,5 – Trimethylbenzene | 0.58 | 0.1 |
| Ethylbenzene | 0.0545 – 7.89 | 0.05 – 5.0 |
| Xylenes (total) | 0.308 – 6.31 | 0.05 – 2.5 |
| **SVOCs** (in mg/kg) | | |
| Benzo(a)anthracene | 0.0113 – 16.8 | 0.0067 – 13.4 |
| Benzo(a)pyrene | 0.0086 – 8.74 | 0.0067 – 13.4 |
| Bis(2-ethylhexyl)phthalate | 3.85 | 2.0 - 100 |
| Chrysene | 0.0071 – 25.0 | 0.0067 – 13.4 |
| Naphthalene | 0.0091 – 11.9 | 0.0067 – 13.4 |
| **Metals** (in mg/kg) | | |
| Arsenic | 2.31 – 16.4 | -- |
| **Analyte** | **Detect Range (min. – max.)** | **MRL range (min. – max.)** |
| Lead | 16.6 – 142 | 10 |
| **TPH** (in mg/kg) | | |
| Aviation Gas Range | 16.1 – 15,100 | -- |

**Chevron Products:**

| **Analyte** | **Detect Range (min. – max.)** | **MRL range (min. – max.)** |
|---|---|---|
| **VOCs** (in mg/kg) | | |
| 1,2,4 – Trimethylbenzene | 5.28 (one detection) | 0.1 |
| Toluene | 0.0635 – 0.517 | 0.05 – 0.5 |
| Xylenes (total) | 0.0552- 2.47 | 0.05 – 0.5 |
| **SVOCs** (in mg/kg) | | |
| Benzo(a)anthracene | 0.0077 – 1.03 | 0.0067 – 1.34 |
| Benzo(a)pyrene | 0.0083 – 1.57 | 0.0067 – 0.335 |
| Benzo(b)fluoranthene | 0.008 – 1.88 | 0.0067 – 0.335 |
| Benzo(k)fluoranthene | 0.0084 – 1.14 | 0.0067 – 0.335 |
| Dibenz(a,h)anthracene | 0.076 – 0.587 | 0.0067 – 0.335 |
| Indeno(1,2,3-cd)pyrene | 0.0068 – 1.37 | 0.0067 – 0.335 |
| Naphthalene | 0.03556 – 0.523 | 0.0067 – 6.7 |
| **Metals** (in mg/kg) | | |
| Arsenic | 1.36 – 5.75 | -- |
| Cadmium | 0.71 – 1.2 | 0.5 |
| Chromium | 7.57 – 24.7 | -- |
| Lead | 15.1 – 24.0 | 10 |

**ConocoPhillips:**

| **Analyte** | **Detect Range (min. – max.)** | **MRL range (min. – max.)** |
|---|---|---|
| **VOCs** (in mg/kg) | | |
| Benzene | 0.0864 – 0.386 | 0.05 – 0.1 |
| Xylenes (total) | 0.0724 – 1.79 | 0.05 – 0.1 |
| **SVOCs** (in mg/kg) | | |
| Benzo(a)anthracene | 0.0084 – 0.408 | 0.0067 – 0.175 |

| | | |
|---|---|---|
| Benzo(a)pyrene | 0.0128 – 0.338 | 0.0067 – 0.175 |
| Benzo(b)fluoranthene | 0.0088 – 0.594 | 0.0067 – 0.175 |
| Chrysene | 0.0096 – 0.322 | 0.0067 – 0.175 |
| Dibenz(a,h)anthracene | 0.0084 – 0.0829 | 0.0067 – 0.175 |
| **Metals** (in mg/kg) | | |
| Barium | 60 – 91.6 | -- |
| Chromium | 12.0 – 18.7 | -- |
| Lead | 13.3 – 29.1 | 10 |
| **TPH** (in mg/kg) | | |
| Gasoline Range | 3.94 – 5.56 | 2.0 – 4.0 |

**BTEX Results**

Laboratory analytical results indicate that the BTEX compounds were detected in seven of the 54 SS samples collected. The detected BTEX concentrations ranged from 77.9 parts per billion (ppb) of toluene in sample G-SS 6 to 6,210 ppb of xylene in sample G-SS 22.

For the subsurface soils, 13 BTEX detections were recorded in the 93 HP and RF samples and two detections were recorded in the 28 UB samples. The detected BTEX concentrations ranged from 54.5 ppb of ethylbenzene in sample G-HP 2 to 13,900 ppb of xylene in sample T-HP 3.

**PAH Results**

During the RI activities, 38 surface soil samples were analyzed for PAHs. These results indicate that low levels of PAHs are present in many areas of the site. These results indicate that the non-carcinogenic PAHs acenaphthene, acenaphthylene, anthracene, benzo(g,h,i)perylene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene were detected in one or more of the surface soil samples. The carcinogenic PAHs benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3,c,d) pyrene were also detected in one or more of the samples.

The samples with non-carcinogenic PAH detections were Chevron samples C-SS-3, C-SS-5, C-SS-6, C-SS-8, C-SS-9, C-SS-11, and C-SS-14, KMLT samples G-SS-2, G-SS-3, G-SS-4, G-SS-6, G-SS-8, G-SS-11, G-SS-13, G-SS-15, G-SS-17, and G-SS-20, ConocoPhillips samples T-SS-3, T-SS-3 DUP, T-SS-9, and T-SS-12. The detected concentrations range from 6,810 ppb (indeno(1,2,3-c,d)pyrene) in C-SS-11 to a maximum phenanthrene concentration of 80,800 ppb in G-SS-6.

The samples with carcinogenic PAH detections included Chevron samples C-SS-3, C-SS-5, C-SS-8, C-SS-9, and C-SS-11, KMLT samples G-SS-2, G-SS-3, G-SS-4, G-SS-6, G-SS-8, G-SS-11, G-SS-13, G-SS-15, G-SS-18, and G-SS-20, ConocoPhillips samples T-SS-3, T-SS-3 DUP, T-SS-9, and T-SS-12. The detected concentrations range from 6,740 ppb (fluoranthene) in C-SS-8 to a maximum chrysene concentration of 25,000 ppb in G-SS-6.

For the subsurface soils, PAH detections were recorded in 73 HP and RF samples and in 29 UB samples. The detected non-carcinogenic PAH concentrations ranged from 6,760 ppb (fluoranthene) in UB-8 to 14,200 ppb of phenanthrene in sample C-RF-1, and the detected

carcinogenic PAH concentrations ranged from 6,700 ppb (benzo(a)anthracene) in UB-8 to 523 ppb of chrysene in sample G-RF-1.

**SVOC Results**

Twenty-three surface samples were submitted for a complete semi-volatile organic compounds (SVOC) analysis. Only one non-PAH SVOC (dibenzofuran) was detected in the samples. This analyte was present in sample C-SS 4 at a concentration of 40 ppb.

Twenty-two HP and RF subsurface soil samples and 10 UB samples were submitted for a complete SVOC analysis. Only one non-PAH SVOC (bis(2-ethylhexyl)phthalate or BEHP) was detected in the samples. This analyte was present in samples G-HP-12, G-HP-13, UB-1, UB-2, UB-6, UB-7, UB-7 DUP, UB-8, and UB-8 DUP. All of these samples were collected from the bottom of Geoprobe borings within the utility trenches located on site. The BEHP concentrations ranged from 3,850 to 5,970 ppb.

**VOC Results**

Twenty-three surface samples were submitted for a complete VOC analysis. Of the 23 samples, two samples (C-SS-12 and G-SS-22) contained detectable VOC compounds. Sample C-SS-12 contained n-butylbenzene, sec-butylbenzene, ethylbenzene, isopropylbenzene, p-isopropyltoluene, naphthalene, n-propylbenzene, 1,2,4-trimethylbenzene, 1,3,5-tri-methyl-benzene, and m,p-xylene. The detected concentrations range from 152 ppb (sec-butylbenzene) to a maximum 1,2,4-trimethylbenzene concentration of 5,280 ppb. Sample G-SS-22 contained n-butylbenzene, sec-butylbenzene, tert-butylbenzene, ethylbenzene, isopropylbenzene, p-isopropyltoluene, n-propylbenzene, 1,2,4-trimethylbenzene, 1,3,5-tri-methylbenzene, o-xylene, and m,p-xylene. The detected concentrations range from 125 ppb (tert-butylbenzene) to a maximum p-isopropylbenzene concentration of 1,280 ppb.

Twenty-two HP and RF samples and 10 UB samples were submitted for a complete VOC analysis. Two samples (C-RF-1 and UB-4) contained detectable VOC compounds. Sample C-RF-1 contained n-butylbenzene, sec-butylbenzene, and n-propylbenzene. The detected concentrations range from 1,360 ppb (tert-butylbenzene) to a maximum n-butylbenzene concentration of 2,290 ppb. Sample UB-4 contained n-butylbenzene, sec-butylbenzene, isopropylbenzene, and n-propylbenzene. The detected concentrations range from 497 ppb (isopropylbenzene) to a maximum n-propylbenzene concentration of 2,430 ppb.

**Metals Results**

Fifteen selected surface soil samples, fourteen subsurface HP and RF samples, and ten UB samples were collected and analyzed for total metals. The metals analyte list for these samples included arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, and zinc. Total arsenic concentrations over the site ranged from 1,360 ppb to 10,500 ppb in surface soils.

Similar arsenic results are seen in the HP, RF, and UB samples, where the range of arsenic is from 1,200 ppb to 288,000 ppb (Table 31b). Arsenic is, however, known to occur naturally at elevated concentrations in the region. The maximum total barium result at the facility was 249,000 ppb at KMLT surface sample location G-SS 21. Barium was detected in all the surface

and subsurface samples. Concentrations of the other targeted metals were below screening levels presented in the RI.

### 10.1.2 Riverbank Samples ☒ Yes ☐ No

The riverbank soil analytical data are included in the above section. The samples with the letters "RF" in the sample name were collected from the riverbank. Figure 3 shows these sampling locations along with the seep sampling and sediment sampling locations.

### 10.1.3 Summary

Adequate information is not available to evaluate the historic management of stormwater across the three facilities relative to potential transport of impacted surface soils from upland areas to the river. This section does, however, provide a summary of the current stormwater management practices at the three facilities. The ability for impacted surface soils to move significant distances by erosion and water transport is very limited. Areas around ASTs and loading/unloading areas are bermed or contained by perimeter walls preventing offsite transport by erosion. Storm and process water generated from the storage tank, truck loading and unloading, former drum reconditioning, and other operational (i.e. potential spill) areas is captured in bermed/walled areas and treated by an oil/water separator and/or other treatment equipment before being discharged to the municipal storm or sanitary sewer systems. Stormwater runoff is collected from roof drains, parking lots, driveways and other non-spill related or operational areas and is directed into catch basins. This water is generally discharged to the municipal storm sewer system without treatment but is very unlikely to contain impacted surface soils. In summary, these facility processes and features serve to severely limit or essentially eliminate the transport of impacted surface soils off-site.

## *10.2 Groundwater*

### 10.2.1 Groundwater Investigations ☒ Yes ☐ No

Groundwater samples have been collected at the three facilities for a number of years. However, it was determined during the RI Work Plan preparation that much of the existing data could not be validated. Therefore, a complete round of groundwater sampling was conducted during October 1997 for the remedial investigation. Currently, all of the wells are gauged on a quarterly basis and a select number of wells are sampled on a semiannual basis (March and September).

### 10.2.2 NAPL (Historic & Current) ☒ Yes ☐ No

During quarterly groundwater monitoring in December 2003, Chevron wells B-7, B-24, CR-6, CR-10, CR-15, CR-19, CR-21A, CR-25, GPW-2, and GPW-3 contained measurable thicknesses of SPH, ranging to 1.45 feet in Well CR-10. During quarterly groundwater monitoring in March 2004, Chevron wells B-7, B-24, CR-10, CR-15, CR-19, CR-21A, CR-25, GPW-2, GPW-3, and GPW-4 contained measurable thicknesses of SPH, ranging to 1.63 feet in Well CR-19 although most SPH thicknesses were less than .5 feet. SPH is removed from the wells monthly by hand bailing. Pneumatic belt skimmers have been installed in wells CR-10 and CR-19. Recovery of SPH is limited. Based on observations during the installation of the new 18-inch diameter storm

drain in December 2003, the SPH occurs in preferential areas at the contact of the fill and underlying silt. The SPH is not a continuous plume on the water table, but residual SPH that is mobilized with seasonal fluctuations in the water table.

KMLT Wells MW-7, MW-22, MW-24, and MW-37 contained measurable thicknesses of SPH, ranging from 0.01 foot in well MW-22 (March 2004) to 0.73 foot in Well MW-7 (March 2004).

ConocoPhillips Wells B-4, B-22A, B-27, B-40, EX-39A, and U-4 contained measurable thicknesses of SPH, ranging from 0.01 foot in Well B-40 (March 2004) to 0.41foot in Well B-27 (March 2004).

### 10.2.3 Dissolved Contaminant Plumes ☒ Yes ☐ No

The Final Upland RI Report presented the complete extent of the groundwater plume. Based upon the groundwater flow and quality data, the extent of petroleum hydrocarbons is described as follows:

- The southwestern edge of the facilities along the Burlington Northern Santa Fe Railroad right-of-way.
- Along NW 61st Avenue along the boundary of the KMLT Terminal.
- A portion of the McCall Oil Company property adjacent to the ConocoPhillips terminal.
- A portion of the CertainTeed Roofing facility.
- Along the shoreline of the Willamette River on the ConocoPhillips and Chevron Terminals.

#### Plume characterization status – complete/incomplete

The plume characterization is complete as presented in the Final Upland RI Report dated August 1, 2003.

#### Plume Extent

See Figures 5 and 6 (attached).

#### Min/Max Detections (Current situation)

Current groundwater sampling is performed on a limited number of groundwater monitoring wells in accordance with DEQ approved monitoring plan. Historical groundwater sampling results are summarized for each of the three terminals that comprise the Willbridge Terminal in Appendix E of the Final Upland Remedial Investigation Report, (KHM Environmental Management, August 1, 2003) and are presented below for the contaminants of concern for groundwater. The table for each of the three terminals shows the minimum and maximum of the concentrations detected above the laboratory MRLs and the range of MRLs.

**Kinder Morgan:**

| Analyte | Detect Range (min. – max.) | MRL range (min. – max.) |
|---|---|---|
| **VOCs** (in µg/L) | | |
| 1,2,4 – Trimethylbenzene | 1,360 (one detection) | 1.0 – 5.0 |
| 1,3,5 – Trimethylbenzene | 5.3 – 327 | 1.0 – 2.0 |
| Benzene | 0.322 – 6,200 | 0.5 – 2.0 |
| Chloroform | 6.79 | 1.0 – 100 |
| Ethylbenzene | 0.379 – 4,880 | 0.5 – 2.0 |
| Toluene | 0.392 – 2,820 | 0.5 – 2.0 |
| Xylenes (total) | 0.759 – 14,900 | 1.0 – 4.0 |
| **SVOCs** (in µg/L) | | |
| Bis(2–ethylhexyl)phthalate | 15.9 | 10 |
| Chrysene | 0.0533 – 583 | 0.05 – 5.0 |
| Naphthalene | 0.064 – 572 | 0.05 – 10 |
| 2–Methylnaphthalene | 108 | 5 |
| **Metals** (in µg/L) | | |
| Arsenic | 1.0 – 162 | 0.1 – 2.0 |
| Lead | 1.0 – 78.6 | 1.0 |

**Chevron Products:**

| Analyte | Detect Range (min. – max.) | MRL range (min. – max.) |
|---|---|---|
| **VOCs** (in µg/L) | | |
| 1,2,4 – Trimethylbenzene | 47.9 (one detection) | 1.0 – 5.0 |
| Benzene | 0.314 – 14,000 | 0.5 – 5.0 |
| Methyl-tertbutyl-ether | 0.9 – 3,200 | 0.5 - 25 |
| Toluene | 0.368 – 6,000 | 0.5 – 50 |
| Xylenes (total) | 0.58 – 5,500 | 0.5 – 10 |
| **SVOCs** (in µg/L) | | |
| Benzo(a)anthracene | 0.01 – 1.36 | 0.05 – 2.5 |
| Benzo(a)pyrene | 0.0628 – 2.47 | 0.05 – 2.5 |
| Benzo(b)fluoranthene | 0.0855 – 2.98 | 0.05 – 2.5 |
| Benzo(k)fluoranthene | 0.1 – 1.3 | 0.05 – 2.5 |
| Indeno(1,2,3-cd)pyrene | 0.0531 – 1.96 | 0.05 – 2.5 |
| Naphthalene | 0.1 – 242 | 0.05 – 12.5 |
| 2–methylnaphthalene | 7.77 – 41.4 | 5.0 – 50 |
| **Metals** (in µg/L) | | |
| Arsenic | 0.5 – 82.7 | 1.0 |
| Cadmium | 0.1 – 35.5 | 0.1 – 5.0 |
| Chromium | 1.0 – 217 | 1.0 |
| Lead | 1.0 – 132 | 1.0 |
| **TPH** (in µg/L) | | |
| Diesel Range | 170 – 210,000 | 50 - 600 |
| Gasoline Range | 51 – 48,000 | 50.0 |

**ConocoPhillips:**

| Analyte | Detect Range (min. – max.) | MRL range (min. – max.) |
|---|---|---|
| **VOCs** (in µg/L) | | |
| 1,2,4 – Trimethylbenzene | 5.42 – 64.5 | 1.0 – 2.0 |
| 1,3,5 – Trimethylbenzene | 1.85 – 36.2 | 1.0 – 2.0 |
| Benzene | 0.355 – 712 | 0.5 – 2.5 |
| n-propylbenzene | 2.49 – 250 | 1.0 |
| Xylenes (total) | 1.16 – 237 | 1.0 – 5.0 |
| **SVOCs** (in µg/L) | | |
| Benzo(a)anthracene | 0.0051 – 29.6 | 0.05 – 5.0 |
| Benzo(b)fluoranthene | 0.0936 – 3.69 | 0.05 – 50 |
| Chrysene | 0.0613 – 13.5 | 0.05 – 25 |
| Naphthalene | 0.16 – 91.2 | 0.05 – 50 |
| **Metals** (in µg/L) | | |
| Arsenic | 1.1 – 897 | 10 |
| Barium | 34.2 – 3,390 | -- |
| Chromium | 1.0 – 317 | 1.0 – 10 |
| Lead | 1.1 – 176 | 1.0 – 10.2 |

## Current Plume Data (using December 2003 data set)

### Plume Map

The groundwater hydrocarbon plume map is presented as Figures 5 and 6. These maps were generated using historic data due to the fact that only a small number of wells are currently sampled at the site. The current groundwater monitoring program includes quarterly gauging of all wells and semiannual sampling of selected wells. The semiannual sampling events occur during March and September of each year to attempt to correspond with low and high groundwater levels. Wells were selected for sampling to monitor the potential movement of the plume in the down-gradient direction. The full extent of the plume is not monitored on a regular basis.

## Preferential Pathways

Based on the Final Upland RI Report dated August 1, 2003 and the groundwater monitoring reports, the groundwater gradient at the Willbridge Facility appears to be toward the Willamette River. Based on the interconnectivity between the shallow groundwater and adjacent surface water, the released material that reached the groundwater including the SPH eventually migrated eastward toward the Willamette River. There appears to be one mitigated and three current specific subsurface migration pathways from the site to the river. The current specific pathways are:

- The mitigated pathway is the backfill around the 60-inch storm water pipeline and outfall which has now been cut off with a 170 foot long sheet pile wall with extraction wells behind the wall to remove and treat impacted groundwater
- The 27-inch sewer or former Holbrook Slough, discussed below.

- Two groundwater seeps located on the KMLT property near the KMLT dock. The two groundwater seeps on the KMLT property that discharge to the Willamette River are potential pathways, however; sampling of these seeps indicate petroleum hydrocarbons are not present. Each of these pathways is described below.

**27-Inch Sewer or Holbrook Slough**

The former Holbrook Slough conveyed excess water from Kittridge Lake to the Willamette River, with a discharge point in the same vicinity as that of the former 27-inch storm outfall. The Holbrook Slough had apparently been filled in with dredge spoils in the early 1900s. Historic maps suggest that the slough originates westward from the Chevron and KMLT properties. In the early 1900s, a 27-inch diameter, wood stave, storm water outfall managed by the City of Portland served the area surrounding the Willbridge Facility and discharged to the Willamette River between the Chevron and Conoco Phillips docks. In 1982, the 27-inch outfall was abandoned and largely removed, with the remaining pipeline grouted with concrete slurry. It was replaced with the 60-inch diameter storm water outfall located to the southeast (upstream).

Current remedial activities to contain the seep include total fluids recovery from the existing Holbrook Trench Recovery System and SPH recovery from a temporary recovery sump at the base of the rip rap slope. A double boom system contains any petroleum sheen in the area of the former outfall.

A cutoff wall is currently being designed to eliminate the seepage of SPH and potentially impacted ground water from the area. The design consists of a near linear, 200-foot-length sheet-pile wall along the shoreline in the area between the Chevron and Conoco Phillips docks. Similar to the existing cutoff wall around the 60-inch outfall, extraction wells will be installed behind the wall to remove impacted groundwater and recovery SPH. The existing treatment system for the 60-inch cutoff wall will be used to separate any recovered SPH and treat impacted groundwater.

**60-Inch Storm Outfall**

The 27-inch diameter storm drain was replaced with a 60-inch diameter storm water outfall located southeast (upstream) from the previous 27-inch outfall location. The construction of the 60-inch storm water pipeline and outfall included installing a bedding of crushed rock and backfill material consisting of loose sand and gravel around the concrete pipe. The portion of the pipeline trench excavated through the river bank appears to have breached a natural ridge in the alluvium that may have prevented or restricted groundwater migration to the river. This breach in the alluvium ridge along with the bedding and backfill material appear to have created a preferential pathway for SPH migration to the river as minor sheens and small amounts of SPH were observed in the vicinity of the 60-inch outfall area for a period following construction of the 60-inch and then beginning again in September of 2000. This pathway has, however, now been eliminated with the installation of a sheet pile cutoff wall around the 60-inch outfall.

### Downgradient Plume Monitoring Points (min/max detections)

The plume downgradient monitoring points are Wells P-1, P-2, U-10, U-11, U-12, MW-33, MW-34 and MW-40, all of which are located near the top of the river bank or along the river bank itself. Samples were collected from these wells in March 2004. These samples were analyzed for BTEX, PAHs, and total metals. BTEX concentrations were not detected in Wells P-1, U-11, U-12, MW-33, MW-34, MW-40, and B-20. BTEX concentrations were detected in P-2, U-10, B-7, B-9, and CR-1 at concentrations ranging from 0.540 µg/l of benzene in Well P-1 to 25.8 µg/l of benzene in Well CR-1, concentrations of toluene ranging from 0.560 µg/L in Well B-9 to 1.13 µg/L in Well CR-1, a concentration of ethylbenzene of 120 µg/L in Well CR-1, and a concentration of xylenes of 9.06 µg/L in Well CR-1.

PAH constituents were not detected in Wells U-10 and MW-33. PAH concentrations were detected in Wells P-1, P-2, U-11, U-12, MW-34, MW-40, B-7, B-9, B-20, and CR-1. The only PAH constituent detected in KMLT Wells MW-34 and MW-40 was acenaphthene at concentrations of 0.0524 and 0.0609 micrograms per liter (µg/l), respectively. The other wells had PAH concentrations detected ranging from 0.0405 µg/l of pyrene in Well P-1 (the only PAH detected in this well) to 5.29 µg/l of fluorine in Well U-11.

### Visual Seep Sample Data ☒ Yes ☐ No

A total of three seep water samples (Seep 1, Seep 2 and Seep 27) were collected from two seep locations on the KMLT terminal (Seep 1 and Seep 2) and one near the ConocoPhillips/Chevron property line (Seep 27). Seep 1 was collected under the KMLT dock. Seep 2 was collected to the north of the KMLT dock in the beach area. These samples were collected during April of 2003. The seep sample from the ConocoPhillips/Chevron property line was collected near the location of the former 27-inch storm sewer outfall. This sample was collected on July 3, 2003.

Laboratory results indicate that the BTEX compounds are not present in any of the seep water samples collected from the two seeps on the KMLT property. The seep sample collected from near the ConocoPhillips/Chevron property line contained toluene at a concentration of 0.751 ppb and total xylenes at a concentration of 1.69 ppb.

The results indicate that there are no PAH compounds in the groundwater collected from the two seeps on the KMLT property. Two PAHs were detected in the seep sample collected near the ConocoPhillips/Chevron property boundary. Acenaphthene was detected at a concentration of 1.07 ppb and fluorene was detected at a concentration of 3.31 ppb.

The seep water samples were analyzed for total and dissolved mercury and zinc. Total mercury was detected at a concentration of 0.000683 ppm in one sample (Seep 1) on the KMLT property. This sample was collected from the seep nearest the dock. Total and dissolved zinc was detected in both samples from the KMLT property. The detected concentrations ranged from 0.00803 ppm (dissolved zinc in Sample Seep-2) to 2.71 ppm (total zinc in Sample Seep 1). No mercury or zinc was detected in the sample from the ConocoPhillips property.

All three samples were analyzed for TPH identification using Northwest Method NWTPH-HCID. TPH as diesel was detected in samples Seep-1 and Seep 27. In addition, TPH as oil was detected in sample Seep 1. These samples were further analyzed for TPH as diesel and oil using Northwest Method TPH-Dx with a silica gel cleanup procedure and without the silica gel cleanup procedure. Concentrations of TPH as diesel and oil were not detected by the analytical method when the silica gel cleanup procedure was used for sample Seep 1. However, TPH as diesel was detected in sample Seep 27 using the silica gel cleanup method at a concentration of 1.42 ppm. Silica gel cleanup is a laboratory procedure that removes non-petroleum compounds (organic material) from the sample material prior to the TPH extraction. Sample Seep 27 was also analyzed for TPH as gasoline. TPH as gasoline was detected in this sample at a concentration of 326 µg/L.

#### Nearshore Porewater Data

This type of data was not collected.

#### GW Plume Temporal Trend

Concentrations of petroleum constituents in groundwater are, in part, related to the presence of separate phase petroleum hydrocarbons (SPH or free product). The number of wells containing SPH and the apparent thickness of SPH within the monitoring wells has varied over the years of monitoring at the site. As a general trend, the average SPH thickness measured in the monitoring wells is declining at each of the three terminal facilities that comprise the Willbridge Terminals site.

The concentrations of petroleum hydrocarbon constituents in groundwater, as measured as part of the on-going groundwater monitoring program, are generally stable or show a decreasing trend.

### 10.2.4 Summary

The remedial investigation activities identified petroleum hydrocarbon concentrations in surface soil, subsurface soil, groundwater, and sediments. Furthermore, SPH has been observed in several of the wells over the history of the site. However, SPH is currently consistently observed in 20 to 23 wells at the facility, depending on hydrologic conditions.

The remedial investigation also determined that the groundwater flow direction is generally towards the cove of the Willamette River where the docks for the terminals are located. There are three significant confirmed or suspected preferential impacted groundwater migration pathways at the site, the Holbrook Slough, fill material at the former 27-inch storm sewer, and the backfill at the 60-inch storm sewer. None of these preferential pathways extend the boundaries of the locality of the facility.

## *10.3 Surface Water*

### 10.3.1 Surface Water Investigation ☒ Yes ☐ No

A total of 13 surface water locations were sampled during the RI field activities. These samples were collected during December of 1998. The surface water samples were collected from points approximately 50 feet off shore from the ordinary high water mark (OHWL) or at 100 feet from the OHWL in the vicinity of the Saltzman Creek and Doane Avenue 60-inch Storm Sewer outfall. The surface water samples were co-located with sediment samples.

These results indicate that the BTEX compounds are not present in any of the surface water samples collected. These results also indicate that non-carcinogenic PAHs were not detected in any of the surface water samples collected. Naphthalene was the only carcinogenic PAH detected in the surface water samples collected. The naphthalene concentration in KMLT sample G-SW 4 was 0.243 ppb.

Selected surface water locations were sampled and analyzed for total and dissolved metals. The metals analyte list for the surface water samples included arsenic, barium, cadmium, copper, chromium, lead, mercury, selenium, silver and zinc.

As expected from river water samples, the total metals results are generally much higher than the dissolved results. Total and dissolved arsenic, cadmium, mercury, selenium and silver were not detected at the laboratory detection limit in any of the surface water samples collected.

The maximum total or dissolved barium result was 23.7 ppb at Chevron sample location C-SW 3.

The maximum total chromium (unspeciated) result was 2.40 ppb (total) in Chevron C-SW 3. The remaining total chromium concentrations are less than 2 ppb. Dissolved chromium was not detected in any of the surface water samples.

The maximum total or dissolved copper result in the surface water samples collected was 3.90 ppb in KMLT G-SW 3.

Total lead concentrations ranged from not detected to 6.80 ppb (G-SW 3). Dissolved lead ranged from not detected to 3.10 ppb in Chevron C-SW 3.

The maximum total or dissolved zinc result in surface water at the facility was 42.6 ppb in ConocoPhillips sample location T-SW 5.

### 10.3.2 General or Individual Stormwater Permit (Current or Past) ☒ Yes ☐ No

The following table presents the current stormwater permits for the three facilities. Information regarding historic permits is not available.

| Permit Type | File Number | Start Date | Outfalls | Parameters/ Frequency |
|---|---|---|---|---|
| **ConocoPhillips** | | | | |
| Stormwater NPDES 1300-J general | OR000138-4 | 2/28/00 | Discharge Locations – Separators 002 and 004 discharge to the storm sewer along Doane Avenue and | Oil & Grease / 2X/Month<br>Sheen / Daily*<br>Flow / Daily*<br>Ethanol / Quarterly |

| | | | | |
|---|---|---|---|---|
| | | | then to the City Outfall (#22?) adjacent to our dock and Separator 001 discharges to the City Outfall (#19 or 19A) near the foot of Kittridge Ave. | pH / twice per year<br>Floating Solids / Visual – twice per year<br>Total Copper / twice per yr<br>Total Lead / twice per yr<br>Total Zinc / twice per yr<br>TSS / twice per yr<br><br>*when discharging |
| **Chevron Products Company** | | | | |
| NPDES General Permit 1300-J | 100122, OR003187-9 | | The facility has two valved discharges that discharge at BES Outfall 22 (60-inch). The valved discharges contain stormwater in the main light products tank yard and the lubricants tank yard. Roof drains and non-contact paved area catch basins (parking areas, package goods loading dock) discharge directly into the BES storm drain system. The parking area by the maintenance building east of NW Front Avenue discharges to the Willamette River under this permit through a private outfall by the Chevron dock. | Same as above |
| **KMLT** | | | | |
| Stormwater NPDES 1300-J general | 32300 | 2/29/00 | Saltzman Creek | Same as above |
| | | | | |
| GEN13 | | | | Standard[1] |

[1] Standard GEN13 permit requirements include flow and oil and grease. Total suspended solids, pH, copper, lead, zinc, ethanol and methyl-t-butyl ether (MTBE) may also be required.

**Do other non-stormwater wastes discharge to the system?** ☐ **Yes** ☒ **No**

### 10.3.3 Stormwater Data ☒ Yes ☐ No

Stormwater analytical data collected in compliance with the facility NPDES permits are available from the facilities if required.

### 10.3.4 Catch Basin Solids Data ☐ Yes ☒ No

### 10.3.5 Wastewater Permit ☒ Yes ☐ No

| Permit Type | File Number | Start Date | Outfalls | Volume | Parameters/ Frequency |
|---|---|---|---|---|---|
| **ConocoPhillips** | | | | | |
| Type – Standard Non-categorical<br><br>Issued by – City of Portland BES | Number – 400.181 | 5/1/03 | Not shown | No limit | pH / Quarterly<br>Total Oil & Grease* / Quarterly<br>Arsenic / Annual<br>Cadmium / Annual<br>Chromium / Annual<br>Copper / Annual<br>Lead / Annual<br>Mercury / Annual<br>Molybdenum / Annual<br>Nickel / Annual<br>Selenium / Annual<br>Silver / Annual<br>Zinc / Annual<br>Cyanide / Annual<br>Sulfide / Annual<br>1,2-Dichloroethane / Annual<br>2,4-Dinitrotoluene / Annual<br>Acrylonitrile / Annual<br>Chlorodane / Annual<br>Chlorobenzene / Annual<br>Chloroform / Annual<br>Nitrobenzene / Annual<br>Pentachlorophenol / Annual<br>Trichloroethylene / Annual<br>* - If Total O&G exceeds 110 mg/l then analyze for polar and non-polar fractions |
| **Chevron Products Company** | | | | | |
| - Wastewater - BES Permit 400.14 | 400.14 | expires 7/01/07 | Not shown | Not provided | Prior to discharge, wastewater is processed through an API separator and a hydrocleaner. Quarterly grab samples are analyzed for pH, oil & grease, and BTEX |

| **KMLT** | | | | | |
|---|---|---|---|---|---|
| City of Portland Environmental Serivces - Industrial wastewater discharge permit | Permit #400.173 | 5/03/01 | Not shown | 10,000 to 25,000 gallons per day | Non-polar oils and grease<br>Benzene<br>Ethylbenzene<br>Toluene<br>Xylenes<br>BOD<br>TSS<br>pH |

**ConocoPhillips Historical Waste Discharge Permits**

Historic wastewater permits information from Chevron and KMLT is not available. The following is the available information regarding historic wastewater permits for the ConocoPhillips facility.

Tosco Corp.

a. Type – Standard Non-categorical
b. Issued by – City of Portland BES
c. Number – 400.137
d. Date Issued – 10/30/02
e. Discharge Volumes – No limit
f. Required Analyses are same as above

Tosco Northwest Company

a. Type – Standard Non-categorical
b. Issued by – City of Portland BES
c. Number – 400.137
d. Date Issued – 8/11/97
e. Discharge Volumes – No limit
f. Required Analyses are:

| Parameter | Frequency | Limit (mg/l) |
|---|---|---|
| pH | Quarterly | 5.0 – 11.5 |
| Oil & Grease(total) | Quarterly | 100 |
| Oil & Grease(polar) | Quarterly | 500 |
| Oil & Grease(non-polar) | Quarterly | 100 |
| BTEX | Quarterly | no limit |
| Chlorinated Hydrocarbons | Annual | 0.5 |
| | | |
| Arsenic | Annual | 0.3 |
| Cadmium | Annual | 0.7 |
| Chromium | Annual | 3.8 |
| Copper | Annual | 2.3 |
| Lead | Annual | 0.7 |
| Mercury | Annual | 0.014 |
| Nickel | Annual | 3.0 |
| Silver | Annual | 0.4 |
| Zinc | Annual | 4.0 |

Required Analyses (continued)

| Parameter | Frequency | Limit (mg/l) |
|---|---|---|
| Sulfate | Annual | 500 |
| Sulfide | Annual | 50 |
| Ammonia | Annual | 50 |
| Phenolics | Annual | 1.0 |
| Closed Cup Flash Point | Annual | <140°F |

Unocal

a. Type – EPA Category 400
b. Issued by – City of Portland BES
c. Number – 400-012
d. Date Issued – 4/30/93
e. Discharge Volumes – No limit
f. Required Analyses are:

| Parameter | Frequency | Limit (mg/l) |
|---|---|---|
| pH | Monthly | 5.5 – 11.5 |
| Oil & Grease (non-polar) | Quarterly | 100 |
| Oil & Grease (polar) | Quarterly | 500* |
| BTEX | Quarterly | no limit |
| Chlorinated Hydrocarbons | Semi-Annual | 0.5 |
| Total Toxic Organics | Semi-Annual | 2.13 |
| Arsenic | Semi-Annual | 0.3 |
| Cadmium | Semi-Annual | 0.7 |
| Chromium | Semi-Annual | 3.8 |
| Copper | Semi-Annual | 2.3 |
| Cyanide | Semi-Annual | 1.2 |
| Lead | Quarterly | 0.7 |
| Mercury | Semi-Annual | 0.014 |
| Nickel | Semi-Annual | 3.0 |
| Silver | Semi-Annual | 0.4 |
| Zinc | Quarterly | 4.0 |
| Sulfate | Quarterly | 500 |
| Sulfide | Semi-Annual | 50 |
| Ammonia | Semi-Annual | 50 |
| Phenolics | Semi-Annual | 1.0 |
| Closed Cup Flash Point | Quarterly | <140°F |

### 10.3.6 Wastewater Data ☒ Yes ☐ No

Wastewater analytical data collected in compliance with the facility's wastewater discharge permits are available from the facilities if required.

### 10.3.7 Summary

Recent documents indicate that the three facilities have been in compliance regarding the individual storm- and wastewater permit requirements.

## *10.4 Sediment*

### 10.4.1 River Sediment Data ☒ Yes ☐ No

A total of 13 river sediment locations were sampled during the RI field activities. These samples were collected during December of 1998. The river sediment samples were collected from points approximately 50 feet off shore from the ordinary high water mark (OHWL) or at 100 feet from the OHWL in the vicinity of the Saltzman Creek and Doane Avenue 60-inch Storm Sewer outfall. The samples were analyzed for BTEX, PAHs, SVOCs, pesticides and metals.

BTEX constituents were not detected in any of the sediment samples.

PAH compounds were detected in eight of the fourteen sediment samples. The detected concentrations ranged from 6.85 ug/kg of fluoranthene in Sample G-SED-4 to 629 ug/kg of fluoranthene in Sample T-SED-3.

Nine of the fourteen sediment samples were analyzed for SVOCs. SVOC compounds were detected in four of the samples at concentrations ranging from 0.00716 mg/kg of benzo(b)fluoranthene in Sample G-SED-2DUP to 0.629 mg/kg of fluoranthene in Sample T-SED-3.

Nine sediment samples were analyzed for pesticides. One pesticide compound (4,4-DDD) was detected in one sample (G-SED-3) at a concentration of 10.6 ug/kg. No other pesticide compounds were detected.

Eleven sediment samples were analyzed for total metals. Each of the eleven samples contained detectable levels of metals. The detected concentrations ranged from 0.651 mg/kg of cadmium in Sample C-SED-2 to 180 mg/kg of barium in Sample C-SED-1.

Table 2 presents the results of this sediment sampling activity.

### 10.4.2 Summary

*[Provide a discussion of what is known of the relationship between upland sources and sediment conditions. This section is expected to be a placeholder until RI data are evaluated for most sites.]*

# 11. CLEANUP HISTORY AND SOURCE CONTROL MEASURES

## *11.1 Soil Cleanup/Source Control*

Soil excavation has been conducted as part of construction projects or responses to accidental releases at the three terminals. These construction activities included the management of petroleum hydrocarbon impacted soil, if encountered. These impacted soils have been typically hauled to Hillsboro Landfill or TPS Technologies. No soil excavation has occurred with the specific intent of source control.

## *11.2 Groundwater Cleanup/Source Control*

### *Containment Booms*

Containment and sorbent booms currently border the shoreline between the Chevron and ConocoPhillips docks and from the south edge of the ConocoPhillips dock to the southern property line (beyond the existing 60-inch stormwater outfall). Additionally, secondary and tertiary containment/sorbent booms are located within the primary boom around the 60-inch stormwater outfall. These booms are intended to contain and recover sheens that may result from the periodic seep at the former 27" outfall/Holbrook Trench and as a redundant protective measure at the 60" outfall.

### *Cutoff Wall*

A cutoff wall was installed during November 2001 through January 2002 to prevent the seepage of SPH from the backfill material surrounding the 60-inch stormwater outfall to the Willamette River. The total length of cutoff wall at the 60-inch outfall is approximately 170 linear feet. The existing cutoff wall is generally "U" shaped to encompass the stormwater outfall trench backfill. The upgradient extent of the cutoff wall, or the ends of the "U"-shaped wall, is keyed into the natural subsurface silt soil ridge that was identified during previous investigations. The downgradient extent of the cutoff wall, or base of the "U"-shaped wall, is approximately centered at the point where the stormwater outfall trench daylights at surface, at the bank of the Willamette River (outfall). The top of the cutoff wall has an elevation of 16.1 feet, City of Portland Datum, which is the approximate ordinary high water elevation at the Site for the Willamette River. A concrete collar was installed at the point where the 60-inch stormwater outfall pipe penetrates the cutoff wall to provide a water-tight seal and prevent the migration of SPH beyond the cutoff wall.

Excavated soils for the cutoff wall installation were temporarily stored on plastic sheeting and covered during field activities. Following profiling of the soil, the excavated soil (approximately 454 tons) was transported to TPS Technologies (TPS) of Portland, Oregon for treatment and disposal. Since the installation of the cutoff wall at the 60-inch outfall, no seepage of SPH has been observed in the vicinity of the 60-inch outfall pipe.

#### *Groundwater Recovery System*

A groundwater extraction and treatment system is operated to maintain the groundwater level and recover SPH behind the cutoff wall. Additional wells are positioned upgradient of the wall along the storm sewer right of way to enhance the recovery of SPH and petroleum hydrocarbon impacted ground water. Extracted SPH and groundwater are treated using an oil/water separator and activated carbon vessels prior to discharge of the treated groundwater to the City of Portland sanitary sewer system (Industrial Wastewater Discharge Permit No. 500.015). The recovered SPH is held in a storage tank at the Site until the SPH is transported to an approved recycler.

#### *Holbrook Trench Recovery System*

The Holbrook Trench Recovery System was installed in 1988 to mitigate an SPH seep at the ConocoPhillips/Chevron property line that resulted in localized sheens on the river. The system consists of an L-shaped trench with a polypropylene liner situated across the mouth of the historic Holbrook Slough and the outfall area of the former 27-inch sewer. A recovery sump is located at the junction of the

two legs. Total fluids were pumped from the sump to the Chevron API separator for treatment and disposal to the City of Portland sanitary sewer system. The system operated from 1988 until 1993 when it was shut down due to lack of SPH recovery. Between 1993 and 2002 only a few sheens of limited extent were noted in the vicinity of the seep. In response to an increase in the frequency of sheens in 2002, the Holbrook Trench Recovery System was reactivated during periods of low river levels since the trench would become flooded with river water above a river level of 7 feet. Operation of the system has continued on an intermittent basis since the summer of 2002.

***Proposed Source Control Actions***

The construction of a second cutoff wall is currently being designed to eliminate the seepage of SPH and potentially impacted ground water from the area of the former 27-inch outfall and Holbrook Slough to the Willamette River. The preliminary design of this second cutoff wall consists of a near linear, 200-foot length sheet-pile wall along the shoreline in the area between the Chevron and ConocoPhillips docks. Similar to the existing cutoff wall around the 60-inch outfall, extraction wells will be installed behind the wall to remove impacted groundwater and recover SPH. The existing treatment system for the 60-inch cutoff wall will be used to separate any recovered SPH and treat impacted groundwater.

**11.2.1**

## *11.3 Other*

In December 2003, the existing storm drain under the alley separating the Light Products Terminal and the Lubricants Plant at the Chevron facility was replaced with an 18-inch diameter welded HDPE pipe. The existing 12-inch diameter concrete pipe had fractures and was acting as a drain for SPH on groundwater to enter the system. A bentonite, CDF cut-off wall with a recovery sump was installed to eliminate SPH migration in the storm drain backfill material. Approximately 2, 500 tons of soil were excavated during construction activities and disposed at Hillsboro Landfill in Hillsboro, Oregon.

## *11.4 Potential for Recontamination from Upland Sources*

Each of the three terminals that compose the Willbridge Terminals Site are still in operation and are currently storing and distributing petroleum products. Therefore, there exists the potential for a release of petroleum products in the future although spill prevention measures taken at all three facilities have resulted in a decrease in the number of releases each year. Additionally, the current and proposed cutoff walls are anticipated to greatly minimize the potential for recontamination of sediments from upland sources at the Chevron and Conoco Phillips terminals. Spill prevention measures have also greatly reduced the number and magnitude of spills from overwater transfer operations at the docks, which further minimizes the recontamination potential.

## 12. BIBLIOGRAPHY/INFORMATION SOURCES

**References cited**
**Other relevant references/information sources**
**Figures:**

- **Figure 1 – (Provided by LWG) Site Features (aerial photo base with outfalls, beaches, Round 1, existing Category 1 & 2 data, planned Round 2 sediment sample locations ). Label adjacent properties to the subject site.**
- **Figure 2 – 1Q04 GW Contour Map**
- **Figure 3 – Riverfront Seep Samples Wall**
- **Figure 4 – Willbridge Geological Cross Section**
- **Figure 5 – Extent of VOCs in Groundwater**
- **Figure 6 – Extent of PAHs in Groundwater**

**Tables:**

- **Table 1: Potential Sources**
- **Table 2: (Provided by LWG) Queried Sediment Chemistry Data (summary statistics only, Category 1 & 2 surface and subsurface data separated). Query boundaries are from site boundaries out to the toe of the channel slope. In Swan Island Lagoon and a few other locations, use best professional judgment.**

**Supplemental Scanned Figures:**

- **Site map**
- **Waste management units (grit piles, tanks, ponds, etc.)**
- **Exploration locations**
- **Soil & Groundwater Information**
- **Source Control/ Remedial Action Information**
- **Stormwater Information**
- **Release Sources**
- **Others as referenced in text**

Battelle. 2002. Assessment of the Nature of PAH in Surface Sediments along the Southwestern Shore of Portland Harbor Superfund Site. Battelle Memorial Institute, Environmental Forensic Investigation Group, Duxbury, MA.

Delta Environmental Consultants 2003. Final Upland Remedial Investigation Report Willbridge Facility, August 1, 2003.

Delta Environmental Consultants 2003. Preliminary Source Control Evaluation Willbridge Facility, April 24, 2003.

DEQ. 2004. DEQ Site Summary Report – Details for Site ID 2355. DEQ Environmental Cleanup Site (ECSI) Database. Accessed February 4, 2004. www.deq.state.or.us/wmc/ecsi/ecsidetail.asp?seqnbr=2355.

DEQ. 1999. DEQ Strategy Recommendation – Name of site. Full date of SR. Site Assessment Program, Oregon Department of Environmental Quality, Portland, OR.

EDR. 2002. EDR Environmental Atlas, Portland Harbor, Multnomah. OR. Environmental Data Resources, Southport, CT.

Groundwater Solutions. 2003. Portland Harbor RI/FS: Upland Groundwater Data Review Report, River Mile 2-11, Lower Willamette River. Prepared for the Lower Willamette Group, Portland, OR. Groundwater Solutions, Inc., Portland, OR.

Integral. In preparation. Round 1 Site Characterization Report. Prepared for Lower Willamette Group, Portland, OR. Integral Consulting, Inc., Olympia, WA. (In text: Integral in prep.)

Integral, Windward, Kennedy/Jenks, Anchor Environmental, and Groundwater Solutions. 2004. Portland Harbor RI/FS Programmatic Work Plan. Prepared for the Lower Willamette Group, Portland, OR. Integral Consulting, Inc., Olympia, WA.

SEA and DEA. 2003. Lower Willamette River May 2003 Multibeam Bathymetric Survey Report. Prepared for the Lower Willamette Group, Portland, OR. Striplin Environmental Associates, Inc., and David Evans Associates, Olympia, WA. (this reference is for Gene's bathymetry info)

Weston. 1998. Portland Harbor Sediment Investigation Report. Prepared for U.S. Environmental Protection Agency. Roy F. Weston, Inc., Portland, OR.